Motif-Enhanced Graph Neural Networks for Recommender Systems

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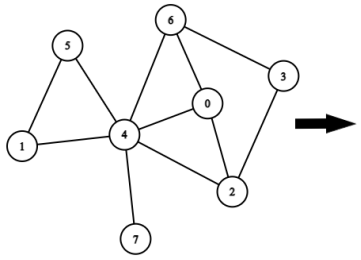
Introduction

We use motif adjacency matrices to enhance performance of Graph Neural Networks (GNNs) on recommender systems.

Network motifs can capture local structural information which is missing from commonly used adjacency matrix. Motifs also represent multiple types of higher-order connectivity between vertices.

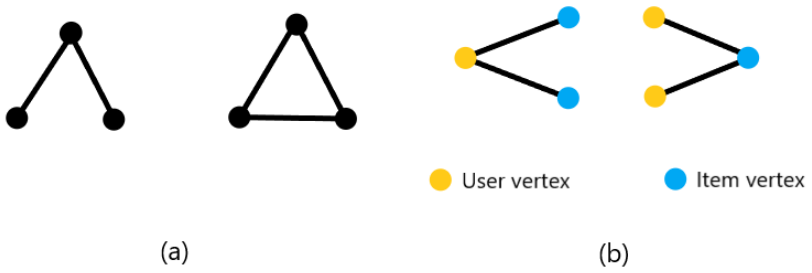
Example adjacency matrix of motif triangle



Adjacency matrix of motif triangle:

$$\begin{bmatrix} 0&0&1&0&1&0&1&0 \\ 0&0&0&0&1&1&0&0 \\ 1&0&0&0&1&0&0&0 \\ 0&0&0&0&0&0&0&0 \\ 1&1&1&0&0&1&1&0 \\ 0&1&0&0&1&0&0&0 \\ 1&0&0&0&1&0&0&0 \\ 0&0&0&0&0&0&0&0 \end{bmatrix}$$

Most datasets for recommendation tasks are structured as bipartite graphs. Because there is no connection between user vertices or between item vertices, the types of motifs are significantly less than in unipartite graphs, making the implementation on GNNs less computationally expensive.

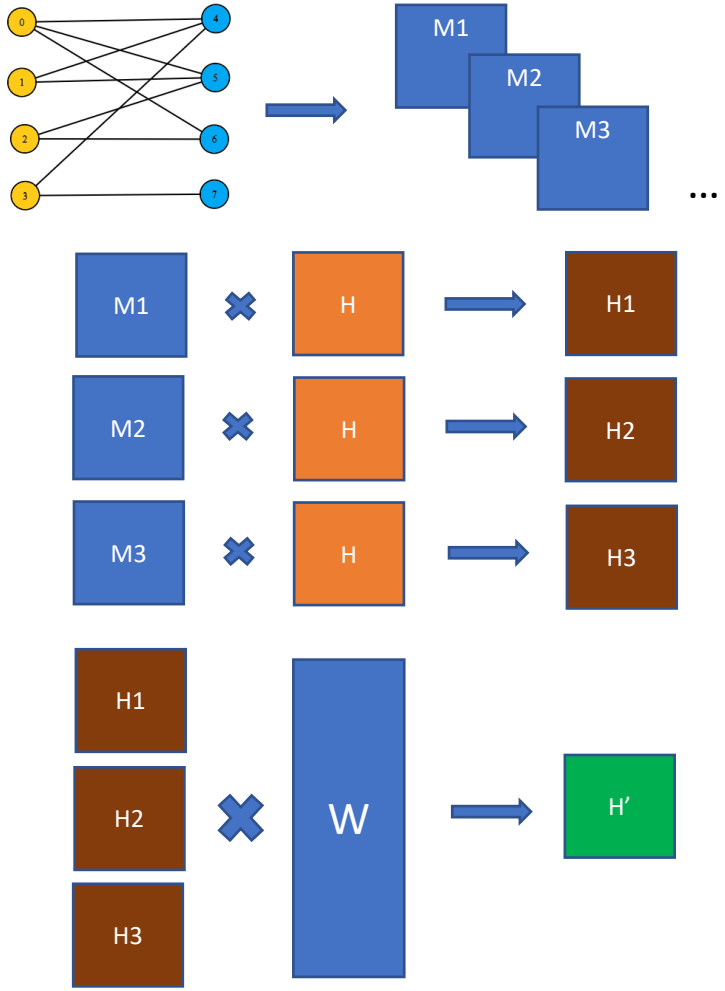


Three-node motifs for unipartite graph (a) and bipartite graph (b)

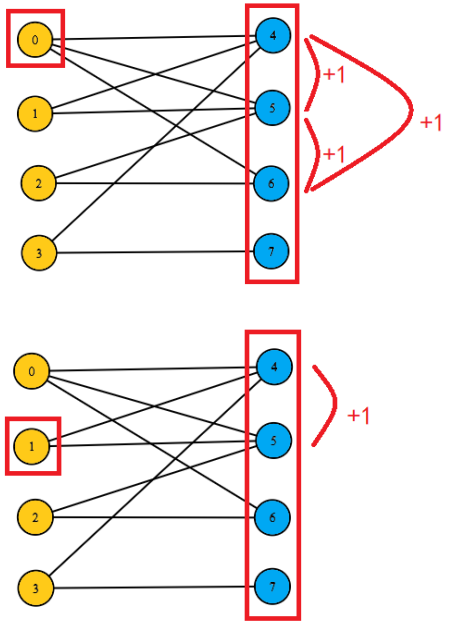
Method overview

We propose a generalised framework to integrate motif adjacency matrices into conventional GNNs:

1. Generating motif adjacency matrices {M1, M2, …}.
2. Message-passing for each motif adjacency matrix.
3. Calculating the weighted sum of feature matrices obtained from step 2.



Example of generating motif adjacency matrices:



Experiments

Results of initial tests on Programmable.com Web-API dataset using Graph Attention Networks in our framework:

Baseline comparison over different p on NDCG metric

p	2	3	4	5	6	7	8	9	10
AMF	0.3321	0.3498	0.3694	0.3972	0.3999	0.4093	0.4109	0.4271	0.4306
NGCF	0.3521	0.3841	0.4393	0.4647	0.4678	0.4580	0.4603	0.4613	0.4647
MISR	0.5209	0.5050	0.5343	0.5301	0.5351	0.5433	0.5569	0.5568	0.5583
HACF	**0.5626**	**0.5666**	**0.5627**	0.5657	0.5711	0.5716	0.5718	0.5725	0.5726
GAT-CF	0.4857	0.529	0.5541	0.5714	0.5843	0.5833	0.5857	0.5834	0.5809
MGAT	0.4857	0.5344	0.5559	**0.5724**	**0.5852**	**0.5843**	**0.5861**	**0.5906**	**0.5889**

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